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AUTHOR Counelis, James Steve
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ABSTRACT

The purpose of this paper is focused toward a systems understanding of the contemporary university, the American University being the data base. A general systems conceptualization called the open systems university is presented. Comprehensive and generic in character, it is hoped that the theory of the open university will be viable enough to fill the lacuna in organizational theory literature on the university. The university can be likened to open systems of the natural types (biological, chemical, or physical systems). All open systems are self-regulating systems. The university is an open system of high complexity, high statistical improbability and order. Its subsystem units are: (1) decision-making bodies, and (2) operational departments. The university is a self-regulating, goal-seeking, open system, which translated into human affairs means freedom and responsibility. The hope is that this open system view of the university will have substantive meaning and be a contribution to the organizational theory about the university; and it is hoped that this view provides useful pragmatic insight for those who lead lives of the university today, wherever the institution is found. The appendix contains the statistical data and charts that accompany the text. (Author/PG)

University of San Francisco
Office of Institutional Studies

San Francisco, California 94117

THE OPEN SYSTEMS UNIVERSITY

by

James Steve Counelis

. . . .But life is an art, the great art, greater than any specialized interest or occupation. We too easily forget that men lived magnificently before science haunted their dreams, magnificently in aspiration, in thought, in action. If we care what happens to mankind, the task confronting us is to bring science within this older and profounder art.

---Max Otto, Science and the Moral Life (1949)

THE UNIVERSITY OF SAN FRANCISCO

Office of Institutional Studies and Management Information

THE OPEN SYSTEMS UNIVERSITY

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James Steve Counelis

World Organization of General Systems
and Cybernetics,
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PREFACE

This study is the culmination of several years of work and writing in the field of higher education. It is an attempt to bring general systems theory into the ken of university scholars of administration and university administrators. Hopefully, it has merit in these directions.

This writer is indebted to many. To Dr. Anthony E. Seidl for his warm encouragement and friendship as Provost of the University of San Francisco. To Mr. Claude J. Rizzo, Vice President for Business and Finance, and to Mr. Ralph A. Stoppel, Controller, for their aid and support. To Dr. Richard G. Peddicord, Assistant Professor of Computer Science, and Mr. Michael A. Kelly, Director of the University Computer Center, for their informative professional and technical assistance. To Mrs. Fran Nishiguchi who made the typescript of this paper possible. And to my family, who missed me while I completed this task, I am indebted for their patience, understanding and love. Of course, all errors rest with the author as they should.

J.S.C.

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by

James Steve Counelis+

Purpose:

The definition of higher education is a function of chronology and culture. Under the rubric "higher education," one finds quite a varied group of institutions. The following is a brief set of historical exemplars of institutions of higher learning as there were understood in their time and culture: (1) the Polynesian whara-wananga; (2) Plato's academy and Aristotle's lyceum; (3) the Alexandrian catechetical school of Pantaenus, Clement and Origin; (4) Byzantium's University of Constantinople; (5) the Sāsānid's academy at Gondēshāpūr; (6) Islam's madrasa and the ᶜAbbāsiᵭ caliph's research centers in Baghdad called Niẓāmīyah and Mustanṣirīyah; (7) India's Guptan university at Nālandā; (8) Japan's daigakuryō, a seventh century college house for training governmental officials; (9) studium generale: the Paris and Bologna models; (10) the English college; (11) the nineteenth century German university; (12) the American community college and the American land grant university. By

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+Dr. James Steve Counelis is Director of the Office of Institutional Studies and Management Information; and, Associate Professor of Education in the School of Education, The University of San Francisco, San Francisco, California 94117, USA.

an historical examination of the end-products of each of these exemplar institutions, an empirical understanding of higher education as higher learning could be derived.

But this paper is not intended to examine the character of the educational productivity of these historic examplars of higher education. Rather the purpose of this paper is focused toward a systems understanding of the contemporary university, the American university being the datal base. Following Sutherland's epistemological platform for general systems theory, this writer will attempt a general systems conceptualization called the open systems university.[1] Comprehensive and generic in character, it is hoped that the theory of the open systems university will be viable enough to fill the current lacuna in organizational theory literature on the university.

Intelligence and the University:

The university can be likened to open systems of the natural types, i.e., biological, chemical and physical systems. This organizational understanding of the university is based upon the work of von Bertalanffy, Boulding, Buckley, Koestler, Laszlo, and others.[2]

All open systems are self-regulating energy systems. Matter and the energy encased therein are imported into the system from the environment. It is "through-put" or transmuted into some product form that characterizes the system. The transformational processes are anabolic

and catabolic, to use the biological terms for build-up and breakdown processes. Also, these processes tend to be in non-reversible time sequence. Once the product is produced, it is exported into the surrounding environment. The cycle begins anew with the system being re-energized from the resources of energy-locked material in the environment.

All natural systems tend toward entropy --- that is, to wind down to a state of randomness, inertia, disorder and death. However, self-regulatory open systems have the capacity to combat entropy by maintaining a steady-state condition at a point that is a significant distance from true equilibrium or death. Thus, open systems are capable of doing work such as keeping in repair and surviving, importing and exporting materials and energy, operating non-reversible processes, and progressively evolving into higher states of complexity and improbability.

All open systems operate under the "challenges" and "stresses" of their environments, as well as operating with the "strengths" and "weaknesses" of their own individual natures. Despite variable initial conditions and after disturbances occurring during the operations of an open system, the same final state or "goal" is achieved by the open system in steady state. This achievement of the same "goal" is the property of equifinality which is a significant dynamic characteristic of open systems.

Another remarkable property of open systems is seen from the perspective of thermodynamics. From this viewpoint, open systems can maintain themselves in a state of high statistical improbability, viz.,

order and organization. According to the second principle of thermodynamics, the general trend of physical processes is toward increasing entropy, viz., states of increasing probability and decreasing order, chaos, tendency toward equilibrium, or death. Living systems maintain themselves in a state of high order and improbability. And thus have the capacity to evolve toward increasing differentiation and organization. The reason is succinctly given by Bertalanffy:

> . . . .In a closed system, entropy always increases according to the Clausius equation:
>
> $$dS \geq 0$$
>
> In an open system, in contrast, the total change of entropy can be written according to Prigogine:
>
> $$dS = d_eS + d_iS,$$
>
> d_eS denoting the change of entropy by import, d_iS the production of entropy due to irreversible processes in the system, such as chemical reactions, diffusion, heat transport, etc. The term d_iS is always positive, according to the second principle [of thermodynamics]; d_eS, entropy transport, may be positive or negative, the latter, e.g., by import of matter as potential carrier of free energy or "negative entropy." This is the basis of the negentropic trend in organismic systems and of Schrodinger's statement that "the organism feeds on negative entropy."3

In parallel form at the societal level of analysis, the university energizes itself from the social, political and economic environment through inputs of material resources, personnel (professional, non-professional, and students), knowledges, ideas and skills. The university organizes, transforms and produces out of the total reservoir of "energy" such things as: (1) physical resources: buildings, laboratories, libraries and equipment; (2) internal services: managerial, instructional,

support; (3) intellectual processes: inquiry, learning, creativity; (4) human capital: educated manpower; (5) products: new sciences, new arts and societal criticism; (6) exportable services: direct social service. When needed, the university re-energizes itself from the environment's bank with new material resources, new personnel, new sciences, new ideas, and new goals to service for community betterment.

By its nature, the university in America has never existed in the state of equilibrium; and history has seen the demise of a good many colleges and universities, especially in recent years of economic distress. The evolved notions of academic freedom, viz., the American translation of Lehrfeiheit and Lernfreiheit, do not admit of equilibrial stances. Neither do the philosophies of the Morrill Act of 1862 and the Hatch Act of 1887 admit of equilibrial conditions. Rather, the steady-state condition of the American university is demonstrated by the tolerance and practice of multiple approaches to inquiry, learning, and curriculum. The negentropic results in American university evolution are illustrated by the wide range of complex organizational arrangements, facilities and curricula of bewildering variety, new arts, new sciences, new technologies, and the greater elaboration of the potential in men.

The university is an open system of high complexity, high statistical improbability and order. It is a complex adaptive organization of open system sub-units. Generically, these sub-system units are: (1) decision-making bodies, e.g., boards of trustees, faculty senates, administrative councils, student governments, union negotiating groups;

(2) operational sub-units, e.g., academic and service department, schools and colleges, quasi-independent programs in curricula or research, intra-organizational committees. Within any given university, the sub-units are energized by planned and budgeted inputs of material resources, personnel, knowledges, ideas and skills. By design and intent these sub-units organize and transform their total reservoir of "energy" into products and services which characterize these sub-units because of their designated division of labor. The products and services produced by these several sub-units are utilized by other sub-units of the university. In turn, the university catenates these products and services into exportable products and services. These exported products and services of the university flow into the community and larger society in which the university resides.[4]

The interchange between an open system and its environment is a significant element in the continued vitality of open systems. The import and export of matter and energy provides a communications link which informs the open system of the nature of the significant "other" in its life processes. Von Foerster's model of the intersect of the environment and organism provides a useful analogue for the university. Von Foerster explains his feedback model in the following terms.

> The diagram shown here below sketches the circular flow of information in the system environment-organism. In the environment constraints generate structure. Structural information is received by the organism which passes this information on to the brain which, in turn, computes the constraints. These are finally tested against the environment by the actions of the organism.

> With the emergence of self-reflection and consciousness in higher organisms a peculiar complication arises. A self-reflecting subject may insist that introspection does not permit him to decide whether the world as he sees it is "real," or just a phantasmagory, a dream, an illusion of his fancy. A decision in this dilemma is important in this discussion, since, if the latter alternative should hold true, no problems as to how organisms represent internally the features of their environment would arise, for all environmental features would be just internal affairs in the first place.
>
> In which sense reality indeed exists for a self-reflecting organism will become clear by the argument that defeats the solipsistic hypothesis. This argument proceeds by reductio ad absurdum of the thesis: "This world is only in my imagination; the only reality is the imagining 'I.'"
>
> Assume for the moment that [a] gentleman in [a] bowler hat . . . insists that he is the sole reality, while everything else appears only in his imagination. However, he cannot deny that his imaginary universe is populated with apparitions that are not unlike himself. Hence, he has to grant them the privilege, that they themselves may insist that they are the sole reality and everything else is only a concoction of their imaginations. On the other hand, they cannot deny that their fantasies are populated by apparitions that are not unlike themselves, one of which may be he, the gentleman with the bowler hat.
>
> With this the circle of contradiction is closed, for if one assumes to be the sole reality, it turns out he is the imagination of someone else who, in turn, insists that he is the sole reality.
>
> The resolution of this paradox establishes the reality of environment through evidence of a second observer. Reality is that which can be witnessed; hence, rests on knowledge that can be shared, that is, "together-knowledge," or conscientia.[5]

[INSERT CHART NO. 1 HERE.]

With this explanatory description of von Foerster's model, the university is presented in these terms in the following section.

For the university corporate processes to operate effectively, the cybernetic requirement of reality-testing as described in the von Foerster model must obtain. Organizational intelligence is the substance of the structural information which reflects the constraints in the larger environment. It is upon this structural information that the university computes the constraints or patterns of invariants found within that environment. Also, the intra-University environment for the several sub-units is reflected in organizational intelligence about that internal environment. It is at this level that most institutional research is focused.

Be they trustees, presidents, deans, faculty, or students, university leaders are the agents concerned for the survival of the institution. They are the agents involved in institutional autonomy and the development of organizational identity. And university leaders are those agents active in the performance of organizational reality-testing. These leaders collect, collate, and integrate many pieces of organizational intelligence upon which they act and/or react through organizational means. As the university evolves into an ever more complex agency, the instrumentation of organizational intelligence becomes an imperative. Larger amounts of the university's resources must go into the intelligence function of the university organization.[6] The creation of an office of institutional research or some comparable agency is a belated recognition of a felt need for university reality-testing to be instrumented. The history of such offices proves this to be the case.

A prolonged hiatus in feedback between an open system and its environment induces crisis in the system. An open system can be starved of information about the constraint patterns within the environment; and serious trauma if not death thus can be caused. The effects of sensory deprivation in human beings are well-known; and the psychic and social effects of distorted human rearing are well documented. Likewise, human organizations, including universities, can be traumatized quite seriously. Distortional sources in organizational intelligence are many. And all organizations in crisis exhibit the pathology of disorientation (and more seriously dissociation), these pathologies arising from reduced reality-testing and the low validity organizational intelligence derived therefrom. Wilensky along with Fink and his associates provide exceptionally clear descriptive patterns of these organizational pathologies arising from inadequate feedback.[7]

As used in this context, institutional research is the formal instrumentation of the organizational intelligence function. The purpose and form of institutional research are, generally, functions of the particular institution's biography. Questions on centralized or decentralized organizational intelligence activity, the line or staff status of the institutional research unit in the university organization, and the particular doctrine(s) on the nature of intelligence held and practiced are answered only by observing the particular university.

The fundamental administrative processes of decision-making, planning, and the management of on-going institutional operations

require immediate knowledge about the status and character of the processes, the products, the services, and the operations of the university in terms of its constituent parts. Of course, the utility of such organizational intelligence is the rational control and continuing guidance of the university while it is in transit toward a set of operational goals which its identity represents. The continuing process called monitoring provides reality-testing information. Two types of monitoring are generally practiced: (1) systematic monitoring; (2) occasional monitoring. Regular sampling procedures, time series data, the budget and the annual audit are examples of systematic monitoring. Ad hoc studies, such as institutional self-studies for periodic accreditation, reflect monitoring for specific reason, occasion, or mission.

Monitoring is not concerned solely with intra-university affairs. Organizational intelligence about the university's environment is crucial to its continued viability. The university's life processes of survival, identity, and autonomy are mirrored in its intersect with the larger society at several levels. The vectors of university relations are toward government and the community, the economic sector, the professions and other social institutions, and the individual. Studies on the institution's graduates and dropouts, the public image and reputation of the university, governmental policies in funding, foundations' attitudes and other aspects of the "out there" world are necessary. But the primary sources of the university's organizational intelligence about the larger community are still rumor and the astute observations by those in university policy positions garnered in their relations with the social environment of the university.

The monitoring processes of the university for both its internal operations and its external relations are known in their dynamic intersect within university decision-making. Buckley presents a general cybernetic model of five stages for a macro-social system. Upon this model, the following discussion is based.

[INSERT CHART NO. 2 HERE.]

Buckley writes of his macro-social model the following description in accord with Chart No. 2:

> In the general cybernetic model of the error-regulating feedback system, we may distinguish . . . five states. 1) A control center establishes certain desired goal parameters and the means by which they may be attained; 2) these goal decisions are transformed by administrative bodies into action outputs, which result in certain effects on the state of the system and its environment; 3) information about these effects are recorded and fed back to the control center; 4) the latter tests this new state of the system against the desired goal parameters to measure the error or deviation of the initial output response; 5) if the error leaves the system outside the limits set by the goal parameters, corrective output action is taken by the control center.[8]

He goes on to caution the reader that this presentation is overly simple and that it is greatly fraught with problems. Nonetheless, the utility of this model for establishing the processual framework for the organizational intelligence function of the university is critical for a dynamic understanding. This Buckley model serves adequately as the pattern of the university, construed as a macro-social system.

A man from Mars, trying to understand the American higher

education landscape, would view it as a veritable jungle of colleges and universities, professional organizations, governmental units layered as a club-style sandwich, consortial arrangements, and communications nets that appear inextricably tangled as a skein of yarn after the work of playful kittens had been accomplished. That appearance is much the same for the new college president. But there is some order to that landscape which is inhabited by colleges and universities. There is a system of macro-organizations which provide national and state direction and leadership, all of them rooted in the twin power bases of the guild of higher education and the loci of power in government and private groups.

The character and range of macro-organizational structures in American higher education is suggested by the Counelis typology for these organizations.[9] On the twin foundations of the basic loci of power and the character of federal structure, Chart No. 3 presents the perspectival pattern to the macro-social world of higher education. Given this typology, the Buckley model takes on a new light.

[INSERT CHART NO. 3 HERE.]

Pragmatically, the university (individually or in association with others) attempts to tap into each stage of Buckley's model. The university lobbies at governmental power centers to help form the goal parameters. The university attempts to influence the administrative decision-making processes at governmental agency levels in areas like "grantsmanship" for facilities and research funding. The university attempts to sound out the pragmatic effects of a given governmental or

non-governmental policy upon themselves and others like them. The university attempts to mold the feedback processes and feedback contents. The university attempts to determine the character of the feedback tests. And the university attempts to effect the character of the corrective measures toward its favor. For the Washington scene, Bloland's Higher Education Associations in a Decentralized Education System (1969) documents this story; and Paltridge's study of California's Coordinating Council for Higher Education (1966) provides a partial view of a state level agency.[10] The Buckley model succinctly maps the tap-points through which organizational intelligence flows to-and-fro between higher education and the public and private power bases in the United States.

Institutional research organizations of universities and their associations contribute directly into the national informational pool on American higher education. Their contributions primarily consist in providing to governmental and non-governmental agencies such organizational intelligence about themselves as are required on demand by the ubiquitous survey questionnaire. Some of the materials, collected year after year, develop into valuable time series for governmental and non-governmental policy development. Other data are collected for ad hoc studies of current concern. Hence, institutional research organizations in American universities contribute to the macro-social monitoring of American higher education. Providing useful comparative inputs, such qualitative statistics very often become criterial referencing instruments for a given university, particular state or federal agency, and private non-governmental organization for specific areas, such as enrollment,

facilities, degrees, financial and cost data, personnel, curricula and other matters.

The Nature of Organizational Intelligence:

In psychodynamic and sociodynamic open systems, common sense and sophisticated inquiries are ambiguity reduction processes through which a person, an institution such as the university, or a whole society constructs a cosmology or Weltanschauung, tests its reality against that cosmology, and references its meaning therefrom.[11] This was well understood by Dewey when he wrote:

> Inquiry is the controlled and directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole.[12]

But are there classes of indeterminate situations which can be treated generically by science? Are there classes of human situations which tend toward ambiguity? This writer believes there are. In fact, this writer asserts that these basic classes of indeterminate and ambiguous situations yield the basic patterns of inquiry that lead to organizational intelligence of the open systems university.

If Aristotle is read aright, he infers that there are several types of human "knowing" situations which tend toward ambiguity or indeterminacy. For him, these human situations are three in number. The first situation is the "What is it?" situation which Aristotle calls

theoretical knowledge.[13] The second is Aristotle's productive knowledge, the human situation being characterized by the instrumental question, "How to do it?"[14] The third is the "What ought to be done?" situation or Aristotle's practical knowledge.[15] Each of these forms of knowledge will be discussed in terms of the university's intelligence function.

By theoretical knowledge, one means a warrantable assertion or proposition derived by answering the generic question, "What is the nature of the case?" Questions like "Who was George Washington?" or "Are solar eclipses predictable?" or "What is the binomial theorem?" are theoretical questions. They reflect the everyday query "What is that?". Answers to theoretical questions are warrantable assertions or propositions, such assertions or propositions being theoretical knowledge. For Aristotle, such knowledge would be the indubitable about the invariant. Hence the denotations for such terms as "fact," "law," and "prediction." But contemporary epistemologists suggest that human knowledge is always partial and fallible and never complete and indubitable.

In symbolic terms, the theoretical assertion would take on the form:

$$\exists X. \qquad [\,]$$

Symbolic Proposition No. 1 reads generically: There exists (perhaps uniquely) an "X" of such character. Thus the proposition "George Washington was the first president of the United States under the federal

constitution, 1789-1797." is a theoretical proposition in the pattern of ∃ X. "The binomial theorem is a mathematical expansion proven by induction." is theoretical proposition. Also a definition of culture constitutes a theoretical sentence. The Aristotelian notion of theoretical knowledge does not refer to the levels of generality or abstraction of a given proposition. Thus, "$s = 1/2\ gt^2$" and "My name is Tom Jones." are both theoretical statements.

Offices of institutional research typically produce studies that are theoretical in kind. Systematic and ad hoc monitoring yield observations. When these are analyzed and structured to meet the need of knowing "What is the nature of the case?", the resulting propositions or conclusions are pieces of reality-testing organizational intelligence for the university. The indeterminate or ambiguous situation takes on the form ∃X. Cost benefit analyses, space studies, student characteristic profiles, CUES inventories, and projections of all types yield propositions which assert the nature of the sought "X."

Productive knowledge refers to an actional proposition that is descriptive of process or method. Intellective and psychomotor skills are involved in such propositions; and when productive propositions are made about human affairs, social interaction skills are the concern. An example of the latter are the Dale Carnegie courses built upon social interactive principles.

Productive propositions are responses to the generic instrumental question "How to do it?". A discernible end-product is

expected. Be the end-product a cake, a dance, or a doctoral dissertation, it is presumed that knowledge of the process or method will provide instrumentally an explicit product.

In a productive knowledge statement, explicit theoretical knowledge is known about the means or process, the ends or the product created, and the predictable and relatively invariant relation between them which is empirically of a causal order. Given these facts, productive knowledge statements are in the following generic symbolic form:

$$\exists X = f \Pi. \qquad [2]$$

The generic reading of Symbolic Proposition No. 2 is: There exists an "X" that is a direct function of process Π. The following are examples of knowledge statements that are productive:

(1) Field testing of examination items (Π) is required in order to produce objective, valid, and reliable questions ($\exists$ X).

(2) Hold your right hand over the piano keyboard with the fingers poised in an arched position above the keys and firmly press each key sequentially (Π) in order to produce the piano tones in that order ($\exists$ X).

In these statements, known means are known to be related causally to known ends, the temporally ordered regime being defined.

Techniques and methodologies --- sets of productive propositions --- have been developed to meet institutional research needs. The Russell-Doi manual for space utilization studies, academic prediction

scales, Koza's system approach to curricular planning and review, and the Judy-Levine CAMPUS simulation model reflect this type of creative work in productive information technology. And there is little doubt that there are a good many more such techniques and methods being developed in offices of institutional research in American universities.

Practical knowledge is concerned with the practical situation of "What ought to be done?". Decision, choice, and preferenced action are the contents of practical statements. Practical knowledge statements have as their aim the guidance and alteration of the course of human affairs while persons are, so to speak, in transit toward their desired goals, be these goals intermediate or ends-in-themselves. Practical knowledge propositions are future-oriented statements, statements guided by purposes, perhaps, the shapes of which are indeterminate from the specific vantage point of the present. The practical statement is guided by axiologically determined ends reflecting the best of what man is capable through deliberate actions and processes known to him.

Whereas the emphasis in productive knowledge statements appears to stress explicit knowledge of particular means in an invariant relation with specific product ends ($M \supset E$), the emphasis of practical knowledge statements appears to mark a probabilistic relation of ends to means, given the fact that a specific end can be achieved through a number of alternative means, some more probable than others, viz., $E \supset K(M_1, M_2 \ldots M_n)$. Here the open systems characteristic of the university, called equifinality, is demonstrated. The deliberating

process required to determine a given alternative which would have efficiency and effectiveness in attaining some desired goal is an inquiry. The result of such an inquiry is a practical knowledge proposition of the following pattern:

$$\exists X = f\ V(pA_n). \qquad [3]$$

Symbolic proposition No. 3 reads generically: There exists an "X" such that it be probably attainable through a particular alternative A_n, selected with the aid of value system V. The form of each alternative in any given set is that of the productive statement, viz., $\exists X = f\ \Pi$. What is sought is an identity between the desired goal and the goal that is attainable through a particular productive proposition. Therefore, the inquiry of practical questions requires the investigation of each alternative as disjunctive "If . . . then." statements with a probability and cost function assigned to each. The selection of a particular alternative is in fact the selection of a particular productive statement which is estimated to have the highest probability of success in achieving the desired goal at an acceptable cost.

To exemplify this process, Dewey presents the following apt commonsense illustration:

> Disjunctive propositions are connected with practical judgment for deliberation upon matters of policy requires (a) that alternative possibilities be instituted and explored, and (b) that they be such as to be readily comparable with one another. For example, a man who has come into possession of a large sum of money proceeds to deliberate as to what he shall do with it. His

> deliberation gets nowhere unless it takes the form of setting up alternative possible uses for the funds at command. Shall it be placed in a savings bank to draw interest? Invested in stocks, in bonds, in real estate? Or shall it be used for purposes of travel, or buy books, apparatus, etc.? The problematic situation is relatively determinate by analysis into alternatives, each of which is representative in a disjunctive proposition as a member of a system.[16]

The deliberative activity in decision-making processes rests upon organizational intelligence of the theoretical and productive types. Both of these types of intelligence are produced by institutional research offices or some other university counterpart. However, the development of practical propositions such as institutional goals, policies, and commitments of the broadest types is the prime responsibility of policy-making officers who require and use reality-testing information for sound judgments that are empirically based. Decision-making is an axiological process; it is not a technical or engineering process. Thus the university officers have two roles to perform. The first is the ante-decisional role of resource information evaluator; the second is the post-decisional role of rational reifier of dreams. What remains to be discussed in this context is the intersect of values, decision-making and the university's institutional integrity to be. But before leaping on towards that axiological discussion, a new role for information theory in organizational intelligence of the open systems university needs to be delineated.

Information Measurement and University Monitoring:

Within the last decade and a half, American higher education

has been going through a management revolution similar to that experienced by American lower schools in the 1920's and early 1930's.[17] The growth of the higher education establishment, the financial constraints on that growth, and the democratization of higher education opportunity required the institutional monitoring of institutional entropy and the planning, budgeting and expending of resources to counter those institutional entropies (negentropy). Hence, this management movement brought with it the demand for an institutional-level computerized management information system (MIS) to replace the less efficient system of manual records. The federal government of the United States has subsidized this higher education MIS movement through the work of the National Center for Higher Education Management System (NCHEMS). This agency in cooperation with the higher education guild has standardized the datal lexicon of American higher education so that time series and other multivariate study can be made on any spectrum or subset of institutions or institutional variables in American higher education. Also, the U.S. Office of Education, through its National Center for Educational Statistics, has standardized through its HEGIS annual survey, a number of variables of higher education that are of peculiar interest to federal education policy. In January 1975, EDSTAT II was inaugurated, as a purchasable service, by the National Center for Educational Statistics, this being a direct computer access system to educational and socio-economic census statistics of the United States.

In the wake of this higher education management revolution

has come the information revolution and the problem of developing such quantities of data into organizational intelligence so that institutional guidance becomes possible through management and organizational intervention. American institutional researchers have developed a broad range of management tools. Also, the Organization for Economic Cooperation and Development, through its Programme on Institutional Management in Higher Education, is working in this field for those European universities who are members of the Centre for Educational Research and Innovation of OECD. It is, nonetheless, quite surprising to note that information theory and information measurement have not been among these higher education measurement tools. To illustrate the utility of information measurement for higher education management, three sets of applications will be presented here. These are:

(1) Theoretical information measurement of the size of university management information (MIS): one illustration;

(2) Information measurement of the quantitative efficiency of university management variables: two illustrations;

(3) Information measurement of the proportional variability of university financial variables: five illustrations.

This writer is very sure that creative and fertile minds will design other useful applications.

Prior to the work of NCHEMS, no one could comprehensively describe the college or university for information measurement purposes. The basic problem was that the descriptive datal categories and datal elements for the university and college had not been designed in

conceptually comprehensive terms. Since the 1973 edition of the NCHEMS Data Element Dictionary, the theoretical calculation of the size of a university management system for one fiscal year was made possible.[18] Chart No. 4 does this, using data from the University of San Francisco for the FY 1973-1974. The rough approximation for information on the University of San Francisco MIS is given to be 80,528 bits. Using a nine-track 800 BPI odd parity tape that is 2400 feet in length, between 3.1 and 38.3 years of University of San Francisco data can be stored on the tape, depending on the programming and other technicalities involved. From this estimate in amount of annual information that could be collected and stored for the most comprehensive serial record of the institution, the University of San Francisco can estimate the costs for collecting, storing and retrieving information for university management purposes.

[INSERT CHART NO. 3 HERE.]

A major problem in university management and planning is the quantitative efficiency of university variables. Here is an excellent opportunity for information theory to help. The theory for this approach was laid by Theil and Lev. In particular, Lev's volume, titled, Accounting and Information Theory, provides succinct treatment and practical guidance in application.[19] Two illustrations on the experience of the University of San Francisco follow.

A problem of budget construction that occurrs annually is the estimation of university income. As a labor intensive enterprise,

the estimated number of clients is related to the estimation of the number of faculty required to service the student clientele as estimated.

With reference to the budgetary estimation of the number of students, the question arises as to whether the number of students serviced or the number of student credit hours in purchased course work is the most efficient variable for income projection. Here the term "efficient" is construed to mean the "most stable" of the two variables, viz., student credit hours (SCH) and student headcount. Chart No. 5 provides an approach using information measurement. By calculating the proportional variability between FY 1973-1974 and FY 1972-1973 within each of the two variables, the information measure (H) for the student credit hours was found to be 74×10^{-5} nits; and the same measure for student headcount was found to be 128×10^{-5} nits. It appears that for the FY 1973-1974 and FY 1972-1973 comparison, the student credit hours factor proportionally varied less than the student headcount. Hence, the student credit hour basis for estimating university tuition income would be a more efficient measure. An annual re-calculation of this information measure is useful so that each biennial change could be known and used.

[INSERT CHART NO. 5 HERE.]

The estimation of the number of faculty members for each fiscal year budget is an annual headache, as well. At the University of San Francisco, an administrative commonsense measure for a full-time

equivalent faculty (FTE) had evolved to be equated to 600 SCH of course instruction per faculty member per academic year. However, there was much that was wrong with this estimate; and the faculty were quite uneasy with such an instructional measure that did not reflect their reality.

This writer developed a statistic for measuring FTE faculty that seemed to take care of many of the faculty objections to the 600 SCH measure. A variable FTE faculty measure was devised to reflect the idiosyncratic curricular patterns of the several colleges and schools of the University of San Francisco. In particular, this variable FTE faculty measure was based upon instructional contact hours, or what this writer calls "instructional effort," eschewing the industrial term "academic productivity" which so violates academic sensibilities.

A comparative study of these two FTE faculty concepts was made. It was found that the administrative commonsense idea of 600 SCH/FTE faculty fully estimated the actual headcount of full-time faculty; but it understated by 43 the member of FTE equivalent faculty needed and used. The comprehensively conceived variable FTE faculty concept more adequately estimates faculty needs and in the right places.[20] However, the question still stands as to the efficiency of each FTE faculty concept. In this case, the term "efficiency" is construed to mean the "amount of information" used in each concept. See Chart No. 6.

In Chart No. 6, the variable FTE faculty concept has an higher H measure than the 600 SCH/FTE faculty concept. With maximum amount of information being equal to the $\log_e 9$ that being .95424 nits.

it is easily seen that the variable FTE faculty concept uses 87% of the total information available; the 600 SCH/FTE faculty concept uses approximately 84% of the total information. Hence, the variable FTE faculty concept more accurately estimates the faculty needs and does so on more information.

[INSERT CHART NO. 6 HERE.]

The ideas for this third set of illustrations of the use of information measures came from the work of Lev. Successfully, he used information theory to estimate comparative information gain/loss of various account aggregation procedures, did financial statement analysis and statistically predicted business failures at a distance of five years prior to failure, evaluated the accuracy of multivariate budgets, their predictions and the information gain/loss achieved by forecast revisions. In this context, five illustrations of the use of information theory applied to the analysis of university financial audits will be presented, using the financial data of the University of San Francisco for this purpose.

Lev sets the theoretical basis for the financial statement analysis in this way:

> A major difficulty in applying information theory concepts is the need to specify explicitly, for each problem, the two sets of probabilities attached to all possible answers: the one prior to the arrival of the message and the other after it. Such specification in the social sciences is rarely practicable. However, informational concepts may be applied in a different context: it is often useful to analyze the decomposition of an aggregate figure

> into its component parts. For example, consumers' expenditures may be divided into the different commodities bought (economics), national income may be classified according to ethnic groups of recipients (sociology), and total assets in a balance sheet decomposed into subgroups of assets (accounting). If the individual components of the decomposition are divided by their total (e.g., current assets and fixed assets each divided by total assets), we obtain a set of nonnegative fractions that sum to one. These fractions may be formally regarded as probabilities, and informational concepts may be applied to such decompositions providing useful descriptive and predictive measures. This kind of application was introduced by Theil, who has proposed a broad range of informational measures for economics, sociology, and business. . .The objective of this monograph is to advance and test the usefulness of such decomposition measures in accounting.[21]

Following this pattern of decomposition, the fractions derived formally become probabilities and information measurement thus is calculated.

The first analysis is to find comparatively the proportional variation of revenues and expenditures between FY 1973-1974 and FY 1972-1973. Chart No. 9 provides the basic data. Using the formula $H = \Sigma\, q_i \log_e(q_i/p_i)$ it was found that the information measures were as follows: (a) Revenue $\underline{H} = 872 \times 10^{-5}$ nits; (b) Expenditure $\underline{H} = 724 \times 10^{-5}$ nits. Hence, the university's revenues proportionally varied more widely than the university's expenditures. This empirically validated the financial intent of the institution for those years.

[INSERT CHART NO. 7 HERE.]

In Chart No. 8, the University of San Francisco's balance sheet data for FY 1973-1974 and FY 1972-1973 are presented for a comparative study of the proportional variability of the university's assets

and liabilities with fund balances. The assets information measure H was found to be 55 x 10^{-5} nits; and the liabilities information measure H was 64 x 10^{-5} nits. Hence, the university's liabilities varied proportionately more than the university's assets between the two fiscal periods. As a "directionless" distance measure between two fiscal periods, the comparison between assets and liabilities proportional variations is a useful pointer to the university fiscal officer to analyze the financial implications of this information measure in the total university context.

[INSERT CHART NO. 8 HERE.]

There will be four separate balance sheet decompositions presented here, using financial data of the University of San Francisco. The proportional variation between FY 1973-1974 and FY 1972-1973 will be measured for each of these balance sheet decompositions. The basic principle of each of these balance sheet decompositions is to determine which two financial variables are to be compared. Each financial variable contains n items (accounts) which total 100%; and each of the n items (accounts) becomes some fraction (construed as a probability) of the whole of the variable. Chart No. 9 presents the results of these balance sheet decompositions.

[INSERT CHART NO. 9 HERE.]

To accomplish these several decompositions and their informational measure, the classification of the university's balance

sheet account into current and fixed categories is required. Accounting practice for non-profit organizations, however, did not admit such a profit/loss categorization of accounts into current and fixed categories. With some trepidation, this writer enlisted the aid of the university's controller to categorize the university's balance sheet accounts in this manner. Reluctantly, he helped; and the categorization is seen in Chart No. 8. For purposes of calculating the informational measures devised, Charts No. 10-11 present these cross-categorizations of accounts for each fiscal year. See Charts Nos. 10-11 at the end of this section.

The first balance sheet decomposition is the assets/liabilities between-group decomposition. The information measure H for this decomposition measures over the two given fiscal periods the proportional variation in current and fixed assets to total assets as well as current and fixed liabilities to total liabilities. Chart No. 9 records these results: (1) assets information measure H: 14×10^{-5} nits; (2) liabilities information measure H: 51×10^{-5} nits. Hence the proportional variation of the university's liabilities for the given fiscal periods varied slightly more than 3.5 times the proportional variation found in the university's assets. This bet of organizational intelligence is reality-testing and should appropriately sensitize university officials as all feedback ought.

The second university balance sheet decomposition is the assets/liabilities within-group decomposition. This information measure H measures the proportional variation of current asset account items to

total current assets; and it measures fixed assets account items to total fixed assets. Similarly, this informational measure H for liabilities is calculated with the same fiscal periods being covered, viz., FY 1973-1974 and FY 1972-1973. Chart No. 9 records these information measures comparatively.

The within-group assets information measures H are: (1) current assets information H = 401 x 10^{-5} nits; (2) fixed assets information H = 28 x 10^{-5} nits. The within-group liabilities information measures H are: (1) current liabilities information = zero nits; (2) fixed liabilities information = 33 x 10^{-5} nits. Comparatively, the proportional variation of the current assets over the two fiscal years in relation to fixed asset proportional variation is over 14 times. The current liabilities information H measures yields the fact that there wasn't any difference in the within-group decomposition between the two fiscal periods. And it is to be noted that the fixed liabilities information H measure varied at the same rate as fixed assets. Administratively and fiscally, these within-group information measures are excellent pieces of organizational intelligence answering in dynamic terms critical theoretical questions as to the nature of the university's finances.

The third balance sheet decomposition is the current items/fixed items decomposition. It provides an informational measure H for the proportional dollar variation over the given fiscal periods of current account items (assets and liabilities) to total current accounts' dollars. Similarly, a second information H measure is calculated for fixed account

items. Chart No. 9 presents the following results: (1) Current Items Information $\underline{H} = 6 \times 10^{-5}$ nits; (2) Fixed Items Information $\underline{H} = .1 \times 10^{-5}$ nits. As would be expected, current items' proportional variation over the two fiscal periods was greater than the proportional variation in the fixed accourts' items.

The fourth decomposition is Theil's time-horizon disaggregation that yields a time-horizon information $\underline{H}$ measure. This informational measure $\underline{H}$ is a time-oriented one which seeks the proportional variation of first years' current assets to the second year's current assets, the first year fixed assets to the second year's fixed assets, the first year's current liabilities to the second year's current liabilities, and the first year's fixed liabilities to the second year's fixed liabilities. The information measure $\underline{H}$ for the University of San Francisco was 32×10^{-5} nits. Inasmuch as the marginal fractions need to be considered to prove the consistence of these measures, a weighted mean of 1 was calculated.[22]

A way of proving the consistency of this information measuresis the calculation of the information $\underline{H}$ in the total balance sheet. This was done. And Chart No. 9 indicates the balance information sheet information to be 33×10^{-5} nits.

The value of all of these decompositional measures for a given institution rests upon the development of a time series of them. These decompositional measures can plot the annual course of such fiscal and budgetary events and give significant organizational intelligence to

the university. Further, cross-institutional comparison of identical measures will provide significant ranges or norms development of such financial measures. In reviewing Cheit's 1971 study, The New Depression in Higher Education, this writer could not find significant institutional data on the 41 institutions in the study to plot out and check Cheit's economic-stress classification of institutions. Indeed, this writer was most disappointed that Cheit did not capitalize on Lev's 1969 work and empiricize his findings beyond the proportion.[23]

The utility of information theory as a tool in university management has been demonstrated. The more accurate the empiricization of university information, the higher the quality of the university's organizational intelligence. But the valuation of that intelligence is more than a matter of magnitude; it is a function of a valuational calculus that needs to be explored a bit.

[INSERT CHARTS NO. 10-11 HERE.]

An Internal University Valuational Calculus:

The open systems university functions precisely in the cybernetic manner described by Buckley's model in Chart No. 3. And within that cybernetic operational pattern, the feedback test, designed to test goal parameters of the institution, provides the organizational intelligence necessary for university reality-testing. Operationally, equifinality is operative in the manner described by Symbolic Proposition

No. 3, viz. $\exists X = f\ V(pA_n)$, given each alternative, A_n, being in the form $\exists X = \ldots$. The impact of the results of the feedback test upon the university is to lead to one of three decisions: (1) continue the original alternative, A_n, as being effective; (2) select another alternative and test it out; (3) restate or select a new goal. With the last option comes the requirement to search for a new set of alternatives in the new goal, the assignment of probabilities and costs to each alternative, the selection, operation and testing of the alternative against the new goal. This process reality-testing needs to be detailed for the open systems university. The following internal valuation calculus is suggested. Its orientation is capsuled in the terms "self-evaluative performance appraisal."

As conceived here, the framework for self-evaluative performance appraisal in the university consists of three fundamental elements. These are: (1) program goals (P); (2) budgeted goals (B); and (3) operational results (O).

Definitionally the term "program goals" (P) refers to the normatively intended achievements for the university. The term "budgeted goals" (B) denotes those normatively intended achievements invested with resource allocations. The term "operational results" (O), means the actual results, holistically obtained through the applied resource investment per normatively intended achievement. In the university context, the following relationship obtains:

$$E = f\ P, B, O. \qquad [4]$$

Symbolic Proposition No. 4 reads: Self-evaluative performance appraisal (E) is a function of program goals (P), budgeted goals (B) and operational results (O). However, the nature of this functional relationship needs further definitional clarity.

The criterion problem is the crux of all evaluation. Within this framework, the criterion is found in the specifically stated program goals (P), viz., the specifically stated normatively intended achievements of the university. The guidance function of program goals (P) are not used systematically in an empirical manner. The suggestion is made here that the university's program goals (P) be taken seriously in an empirical sense. Surely if they are intended, they must be observable. If they are observable to someone on campus, they should be observable to all.

Admitting that the university's program goals (P) are general in character does not vitiate their observable quality. And when one program goal (P) is allocated resources, the budgeted goal (B) ought to become more clearly perceived in empirical terms. It is when the budgeted goals (B) and the actual results, here called generically by the term "operational results" (O), are compared and contrasted that evaluation obtains.

Put at a more generic level, it is the function of program goals (P) to provide specific guidance to the university's resource allocation patterns. It is the function of budgeted goals (B) to delineate

in specific empirical and programatic terms the goals marked for achievement. And it is the function of operational results (O) to embody the specific achievement stated in the budgeted goals (B) which in turn reflects the general university program goals and mission (P). The key terms in evaluation are those of comparison (similarity) and contrast (difference) between criterion (P and B) and results (O). Symbolically, self-evaluative performance appraisal in the university (E) is defined:

$$E = f\, P_n\, [(B_n \sim O_n)\, .\, (B_n - O_n)]. \qquad [5]$$

Symbolic Proposition No. 5 reads: "elf-evaluative performance appraisal (E) is defined as a function of the similarities ($B \sim O$) and differences ($B - O$) between budgeted goals (B) and operational results (O) under direct guidance of the university's program goals (P).

The pragmatic test of institutional achievement of the university is in the degree of congruence among the elements of evaluation, viz., program goals (P), budgeted goals (B), and operational results (O). A low degree of congruence among P, B, and O indicates a low level of achievement, a "red flag" for self-examination and feedback for corrective action. A high degree of congruence indicates substantive achievement of intended goals. Symbolic representation of the test of congruence is indicated as follows:

$$Z_n = f\, P_n \cong B_n \cong O_n. \qquad [6]$$

Symbolic Proposition No. 6 reads: Achievement (Z_n) is a function of the degree of congruence among program goals (P_n), budgeted goals (B_n), and operational results (O_n), each goal taken individually rather than severally.

In Symbolic Proposition No. 6 there are three formal relationships that produce the intended congruence among P_n, B_n, and O_n. These are: (1) $P_n \cong B_n$; (2) $P_n \cong O_n$; and (3) $B_n \cong O_n$. These three relationships provide the analytical tools for achievement accountability. The statement $P_n \cong O_n$ asserts the formal and substantive agreement to be found between particular program goals (P_n) and particular budgeted goals (B_n). The statement $P_n \cong O_n$ asserts the formal and substantive agreement to be found between particular program goals (P_n) and particular operational results (O_n). The statement $B_n \cong O_n$ asserts the formal and substantive agreement to be found between particular budgeted goals and particular operational results. In institutional self-evaluation, these three analytic propositions collectively provide the specific feedback tests given in Buckley's model, hopefully, to help to "zero in" on the focal point of disparity between achievement and non-achievement for each reporting unit's specific goals taken individually and severally.

There are two structural dimensions to the university. The vertical dimension designates the hierarchical levels of university organization. These levels commonly are: (1) university-as-a-whole level (U); (2) school/college level (C); (3) departmental level (D), i.e.,

academic and non academic; (4) personnel level (L), i.e., the individual professional and support staff people.

The horizontal dimension of the university designates the general university elements which cut across all the hierarchical levels. These general elements are: (1) faculty (F); (2) curriculum (K); (3) students (S); and (4) milieu (M). Within milieu (M) is comprehended the following: (a) milieu: administration (M_a); (b) milieu: governance (M_g): (c) milieu: plant/environment (M_p); (d) milieu: external relations (M_e). The cross classification of these two dimensions provides a systematic pinpointing of areas in the university structure in which self-evaluative performance appraisal can take place. The attachment of particular program goals (P), budgeted goals (B), and operational results (O) to the university's organization by areas provides a systematic evaluational plan or format to "blanket" the university in its entirety.

This calculus for university self-evaluation performance appraisal never fully obtains in the real university world. It is too aseptic. The university around the world is a particularly human institution with its messiness, formalisms and myopias. And in fact, most university variables with which this writer is familiar tend to be moderately stochastic in character rather than deterministic.[24]

The above formalizations, Symbolic Propositions Nos. 4-6, provide a useful generic view of the open systems university's cybernetic reality-testing structure. This cybernetic test structure is the path of organizational intelligence being used in university monitoring, com-

of which is systematic and some being occasional. For the open systems university to survive, reality-testing through university monitoring, here called university self-evaluation performance appraisal, must obtain. University student rioting in the 1960's and the unionization of American university faculties in the 1970's are symptoms of the lack of reality-testing in the university. And many recall, that universities did come to a halt and almost died.

The open systems university requires organizational intelligence --- not just information --- to survive. Though policy makers and educational practitioners can carry on for a considerable length of time with organizational intelligence of low validity, the gradual and cumulative results of low validity intelligence is organizational crisis. Institutional integrity and survival places all in the university under a categorical imperative to fulfill its mission. But more sitnificantly, this categorical imperative rests as a creative opportunity upon the total university as a community, no less for the trustee and president than for faculty, students and the many highly valued service personnel.

Fact and Justification:

To view the university as an open system does not depreciate it. Indeed universities owe their existence to the value structure of a given social system in time and place. Further, the university like all societal structuresis directed and dominated by a

kind of truncated Kantian categorical imperative --- the duty to fulfill its mission and aims. This very difficult duty sets the university's goals as criteria against which reality is tested and measured.

Decision-making in the university ought to be an ethical affair --- an explicit ethical affair. Though a given university's aims and policies provide some closure on such valuational matters, the significance and efficiency of the university's own ultimate moral justification requires the study of its metaethical principles. The hope is an expectation that the university processes of conscious and rational ethical discourse be used to work through to an ultimate justification of the university in a particular instance. After this ethical study, institutional decision-making becomes qualitatively better and sharper. Intent and reality become merged within the vitals of the social process that is the university. The public secular university no less than the private and religiously-oriented institution has the obligation for continuing ethical self-examination. Daily our student clients and some faculty are reminding us of that duty.

Sir Francis Bacon stated that knowledge is power. But it is the nature of power to be amoral, undifferentiated in effect, and incompetent. Only the highest validated values of the university can inspire the self-regulated use of organizational intelligence toward achieving its highest and brightest ends. It is apt for this writer to paraphrase the philosopher David Hume by writing that ideals without facts are empty and facts without ideals are blind. [25]

Epilogue:

The synthesis presented here of the university as an open-system is a dynamically human perception of reality. Organizational intelligence and its varieties, information measures and their precision, monitoring and reality-testing, the university self-appraisal performance calculus, and the university's meta-ethical study of its ultimate justification emphasize the structural character of the cybernetic system that is the university, generically conceived. That other views of the university are valid is not questioned. The hope is, however, that this open systems view of the university will have substantive meaning and be a contribution to the organizational theory on the university; and it is hoped that this view provides useful pragmatic insight for those who lead lives of the university today, wherever this institution is found. The university is a self-regulating goal-seeking open system, which translated into the human affairs means freedom and responsibility.

FOOTNOTES

1. John W. Sutherland, A General Systems Philosophy for the Social and Behavioral Sciences (New York: George Braziller, 1973), pp. 19-20.

2. Some of the materials to which this writer is indebted are the following: (1) Ludwig von Bertalanffy, General Sustems Theory: Foundations, Development, Applications (New York: George Braziller, 1968), (2) Kenneth Boulding, "General Systems Theory-the Skeleton of of Science," Management Science, Vol II (1956), pp. 197-208; (3) Walter Buckley, Sociology and Modern Systems Theory (Englewood Cliffs, N.J.: Prentice-Hall, 1967); (4) _____, (ed.), Modern Systems Research for the Behavioral Scientist: A Sourcebook (Chicago, Ill.: Aldine Publ shing Company, 1968); (5) Glenn L. Immegart and Francis J. Pilecki, An Introduction to Systems for the Educational Administration (Reading, Mass.: Addison-Wesley Publishing Company, 1973); (6) George J. Klir (ed.), Trends in General Systems Theory (New York: Wiley-Interscience, 1972); (7) William Gray and Nicholas D. Rizzo (eds.), Unity through Diversity: A Festschrift for Ludwig von Bertalanffy (New York: Gordon and Breach Science Publishers, 1973), 2 vols.; (7) Arthur Koestler, "General Properties of Open Hierarchical Systems (O.H.S.)," in The Ghost in the Machine, by Arthur Koestler (New York: The Macmillan Company, 1967), pp. 341-348; (9) Ervin Laszlo, Introduction to Systems Philosophy: Toward a New Paradigm of Contemporary Thought (New York: Gordon and Breach, Science Publishers, 1972); (10) James G. Miller, "Toward a General Theory for the Behavioral Sciences," in The State of the Social Sciences: Papers Presented at the 25th Anniversary of the Social Science Research Building, The University of Chicago, November 10-12, 1955, Edited by Leonard D. White (Chicago, Ill.: The University of Chicago Press, 1956), pp. 29-65; (11) Talcott Parsons, et al., The American University (Cambridge, Mass.: Howard University Press, 1973); (12) Sutherland, op. cit.; (13) Paul A. Weiss (ed.), Hierarchically Organized Systems in Theory and Practice (New York: Hafner Publishing Company, 1971); (14) Alfred Kuhn, The Logic of Social Systems (San Francisco, Ca.: Jossey-Bass Publishers, 1974).

3. Bertalanffy, op. cit., p. 144.

4. There is an extensive substantive literature documenting the systems understanding of educational enterprises. Examples of this literature are: (1) Philip G. Albach, et al., Academic Super Market: A critical Case Study of a Multiversity (San Francisco, Ca.): Jossey-Bass, Inc., 1971); (2) James Steve Counelis, American Government, Higher Education and the Bar (Ph.D. dissertation on Library of Congress Microfilm; Chicago, Ill.: The University of Chicago/Department of Education, 1961); (3) Jacob W. Getzels, et al., Educational Administration as a Social Process: Theory, Research. Practice (New York: Harper and Row, 1958);

(4) D. Kent Halstead, Statewide Planning in Higher Education (OE73-17002; Washington, D.C.: U.S. Department of Health, Education and Welfare, Office of Education, 1974); (5) W. Roy Niblett and R. Freeman Butts (eds.) Universities Facing the Future (San Francisco, Ca.: Jossey-Bass, Inc., 1972); (6) Lawrence P. Nordell, A Dynamic Input-Output Model of the California Educational System (Technical Report No. 25; Berkeley, Ca.: University of California/Center for Research in Management Science 1967); (7) Organization for Economic Co-operation and Development, Mathematical Models in Educational Planning (Paris: 1967); (8) _____, Mathematical Models for the Education Sector (Paris: 1974); (9) Parsons, et al., op. cit.; (10) George Psacharopoulos, Return to Education: An International Comparison (San Francisco, Ca.: Jossey-Bass, Inc., 1973); (11) Barry M. Richman and Richard N. Farmer, Leadership, Goals, and Power in Higher Education (San Francisco, Ca.: Jossey-Bass, Inc., 1974); (12) Study Group in the Economics of Education, Residual Factor and Economic Growth (Paris: Organization for Economic Cooperation and Development, 1964); (13) George B. Weathersby and Deanna Nash, A Context for Policy Research in Financing Postsecondary Education (Washington, D.C.: The National Commission for the Financing of Postsecondary Education, 1974).

5. Heinz von Foerster, "From Stimulus to Symbol: The Economy of Biological Computation," in Berkeley, Modern System Research, op. cit., pp. 172-173.

6. For a current understanding of institutional research in American institutions of higher education, see, Paul L. Dressel, et al., Institutional Research in the University (San Francisco, Ca.: Jossey-Bass, Inc., 1971). See also the publications of the Association for Institutional Research, a professional organization for institutional researchers.

7. On organizational pathologies, see: (1) Steven L. Fink, et al., "Organizational Crisis and Change," The Journal of Applied Behavioral Science, Vol. VII, No. 1 (January-February, 1971), pp. 15-37; (2) Harold L. Wilensky, Organizational Intelligence: Knowledge and Policy in Government and Industry (New York: Basic Books, Inc., 1967), pp. 10-15.

8. Buckley, Sociology, op. cit., pp. 173-174.

9. James Steve Counelis, Macro-Administration in American Higher Education: Some Research Directions (ERIC No. ED 031 995; University Park, Pa.: The Pennsylvania State University/College of Education, 1967), pp. 11-17, 31-32.

10. Harland G. Bloland, Higher Education Associations in a

Decentralized Education System (Berkeley, Ca.: University of California Center for Research and Development in Higher Education, 1969); and, James G. Partridge, California's Coordinating Council for Higher Education: A Study of Organizational Growth and Change (Berkeley, Ca.: University of California Center for Research and Development in Higher Education, 1966).

11. For significant papers in this area, see: (1) Peter L. Berger and Thomas Luckman, The Social Construction of Reality: A Treatise in the Sociology of Knowledge (A589; Garden City, N.J.: Anchor Books, 1967); (2) Peter L. Berger, The Sacred Canopy: Elements of a Sociological Theory of Religion (A658; Garden City, N.J.: Anchor Books, 1969).

12. John Dewey, Logic: The Theory of Inquiry (New York: Henry Hold and Company, 1938), pp. 104-105.

13. Aristotle, Physica, ii.1, 3.194b16-195a26; An. Post. ii.19.99b15-100b18; Metaphysica, i.1980a21-981b10; Ethica Nicom., vi.3, 6.

14. Aristotle, Ethica Nicom., vi. 4, 5, 7.

15. Aristotle, An. Post., i.33.88b30-89a39; Ethica Nicom., i.3.1094b12-1094b29; iii, vi. 8, 9.

16. Dewey, op. cit., p. 171.

17. Raymond E. Callahan, Education and the Cult of Efficiency: A Study of the Social Forces that have Shaped the Administration of the Public Schools (Chicago, Ill.: The University of Chicago Press, 1962).

18. Suzette Goddard, et al., Data Element Dictionary (2d ed.; Boulder, Co.: National Center for Higher Education Management Systems/WICHE, 1973).

19. Baruch Lev, Accounting and Information Theory ([New York]: American Accounting Association, 1969). See also: (1) Leon Brillouin, Science and Information Theory (2d ed.; New York, N.Y.: Academic Press, Inc., 1962); (2) Jagjit Singh, Great Ideas in Information Theory, Language and Cybernetics (New York, N.Y.: Dover Publications, Inc., 1966).

20. James Steve Counelis, University Budget Planning, Regression Estimates of Credit, and the Concept of the FTE Faculty (ERIC No. ED 096 939; San Francisco, Ca.: The University of San Francisco/Office of Institutional Studies and Management Information, 1974), pp. 1-8; and _____, "Academic Productivity and Institutional-Level Theory: Unobtrusive Measures for the Under-Computerized Institution," in Public Policy: Issues and Analyses --- Selections from the 14th Annual Forum. Edited by Robert G. Cope ([Seattle, Wa.]: The Association for Institutional Research and the University of Washington, 1974), pp. 49-57. For recent work on measurement stability, see: Lee J. Cronbach, et al., The Dependability of Behavioral Measurements: Theory for Generalizability for Scores and Profiles (New York, N.Y.: John Wiley and Sons, Inc., 1972). Additionally, the basic unit of information H used in this paper is the nit rather than the bit or Hartley, viz., the calculations in natural logarithms.

21. Lev, op. cit., pp. 1-2.

22. Ibid., pp. 23-27.

23. Earl F. Cheit, The New Depression in Higher Education: A Study of Financial Conditions at 41 Colleges and Universities (New York: McGraw-Hill Book Company, 1971).

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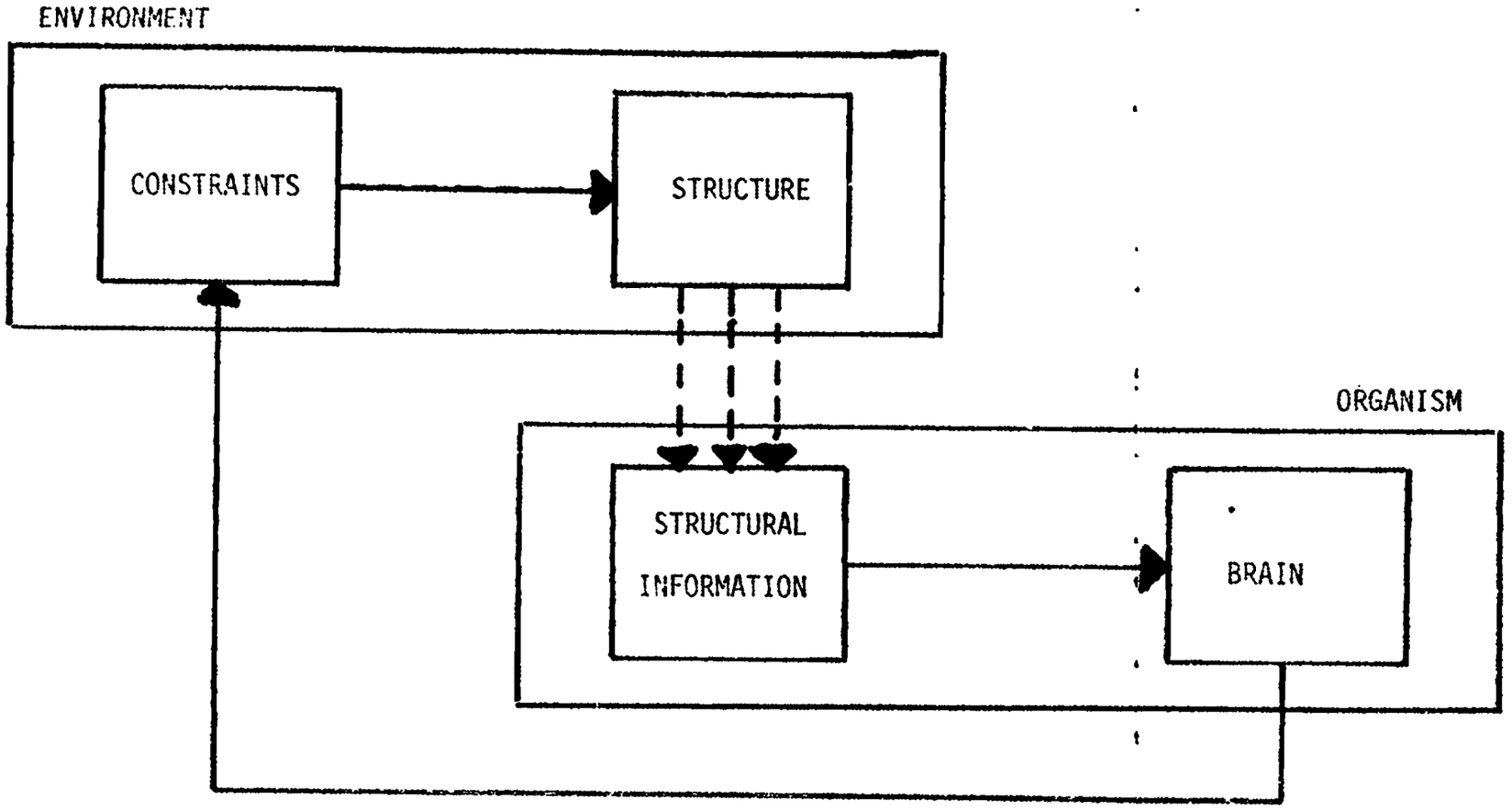
pp. 205-227; (6) A. Phillips Griffiths, "Ultimate Moral Principles: Their Justification," The Encyclopedia of Philosophy (1969), Vol. VIII, pp. 177-182; Clyde Kluckhohn, "Values and Value Orientations in the Theory of Action: An Exploration in Definition and Classification," in Toward a General Theory of Action, Edited by Talcott Parsons and Edward A. Shils (Cambridge, Mass.: Howard University Press, 1959), pp. 388-433.

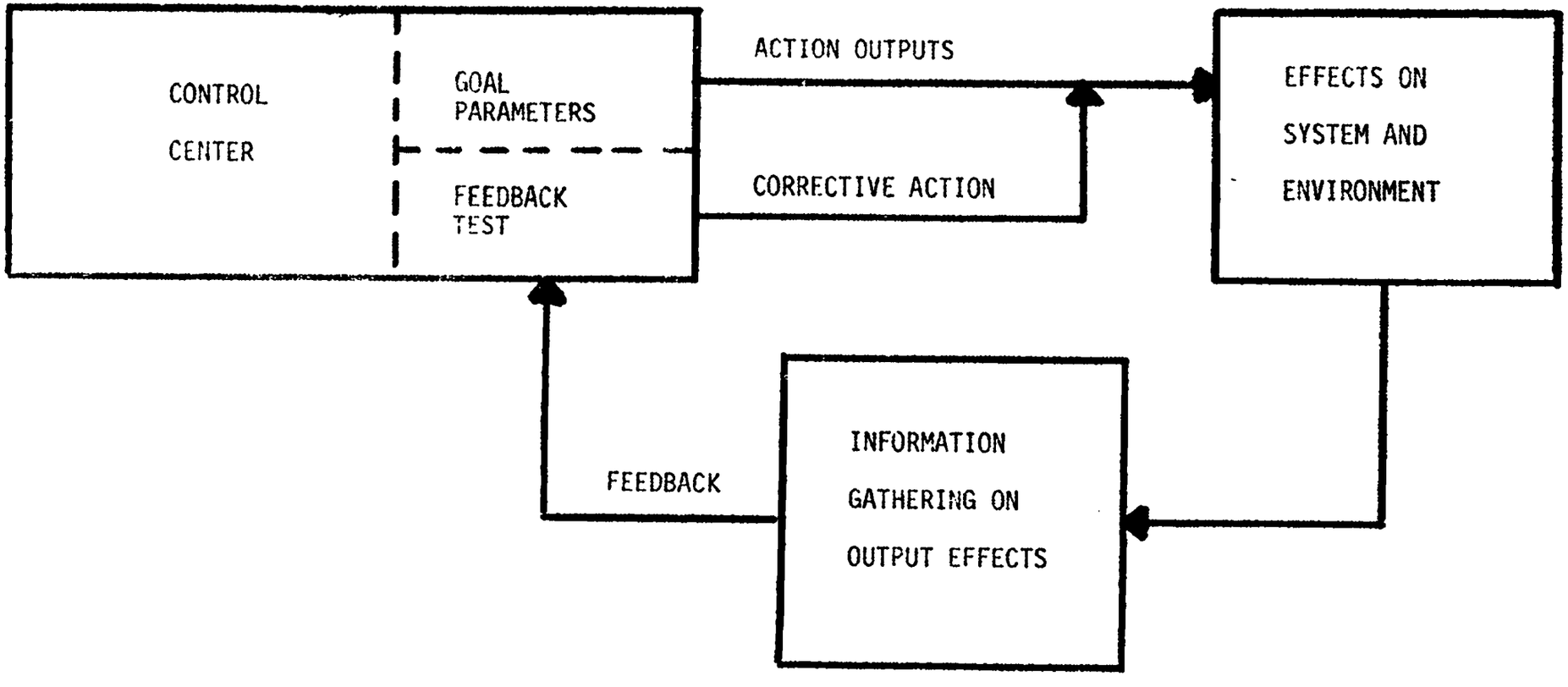
APPENDIX

CHART NO. 1: THE VON FOERSTER FEEDBACK MODEL



Source: Heinz von Foerster, "From Stimulus to Symbol: The Economy of Biological Computation," in Walter Buckley (ed.), Modern Systems Research for the Behavioral Scientist: A Source Book (Chicago, Ill.: Aldine Publishing Company, 1968), pp. 170 - 181.

CHART NO. 2: THE BUCKLEY GENERAL CYBERNETIC MODEL OF A MACRO-SOCIAL SYSTEM



Source: Walter Buckley, Sociology and Modern Systems Theory (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), p. 173.

CHART NO. 3: THE COUNELIS TYPOLOGY OF AMERICAN HIGHER EDUCATION MACRO - ORGANIZATIONS

		AMERICAN HIGHER EDUCATION MACRO - ORGANIZATIONS	
		TRANS-SOCIETAL: GOVERNMENT POWER LOGUS	TRANS-INSTITUTIONAL: INSTITUTIONAL POWER LOGUS
FEDERAL PATTERNS	CENTRALIZED	State Governing Boards	Professional Associations: Institutions and Persons
	PERIPHERALIZED	State Voluntary Co-ordinating Agency Regional and National Compacts	Bilateral and Multi Lateral Consortia, Arrangements and Agreements

Source: James Steve Counelis, Macro-Administration in American Higher Education: Some Research Directions (ERIC No. ED 031 995; University Park, PA.: The Pennsylvania State University/College of Education, 1967).

CHART NO. 4: THE THEORETICAL CALCULATION OF THE SIZE OF A UNIVERSITY MANAGEMENT INFORMATION SYSTEM: THE UNIVERSITY OF SAN FRANCISCO EXAMPLE

NCHEMS DATAL CATEGORIES	NUMBER (X) OF NCHEMS DATAL ELEMENTS		NUMBER (N) OF USF UNITS		H = N Log_2 X (bits)
	X	Log_2 X	N*	UNIT	
Courses	34	5.087463	3300	Course Sections: 150 HEGIS Disciplines Taught	16,789
Facilities	34	5.087463	1388	Rooms: 38 HEGIS Type Facilities	7,061
Finance	13	3.700440	4000	Accounts: 650 Departments	14,802
Staff	64	6.000000	850	Employees: All Groups	5,100
Students	70	6.129283	6000	Students: All Groups	36,776
University Total System H For One Year	—	----	----	----------	80,528

* Actual Frequencies
** Simplicity of Example

CHART NO. 5: INFORMATION MEASUREMENT OF QUANTITATIVE EFFICIENCY OF PREDICTIVE UNIVERSITY VARIABLES-STUDENT CREDIT HOURS AND STUDENT HEADCOUNT: THE UNIVERSITY OF SAN FRANCISCO EXAMPLE

COLLEGE/SCHOOL	STUDENT CREDIT HOURS				STUDENT HEADCOUNT			
	FY 1973-1974		FY 1972-1973		FY 1973-1974		FY 1972-1973	
	N	PROPORTION	N	PROPORTION	N	PROPORTION	N	PROPORTION
Business Administration	12,348	.08049	11,846	.07521	1.663	.11335	1,742	.11292
Education	10,554	.06880	9,690	.06152	1,824	.12432	1,740	.11279
Evening College	19,408	.12651	20,660	.13116	2,414	.16453	2,389	.15486
Law	17,931	.11688	18,550	.11777	1.638	.11164	1,666	.10799
Liberal Arts	64,799	.42238	69,659	.44225	4,328	.29498	5,055	.32767
Nursing	6,818	.04444	6,133	.03894	1,048	.07143	1,006	.06521
Science	21,555	.14050	20,973	.13315	1,757	.11975	1,829	.11856
Total	153,413	1.00000	157,511	1.00000	14,672	1.00000	15,427	1.00000

Source:

Records, Office of Institutional Studies/Management Information, University of San Francisco.

SCH Information (H) = 74×10^{-5} Nits
Student Headcount Information (H) = 178×10^{-5} Nits

$$H = \sum q_i \log_e (q_i/p_i)$$

CHART NO. 6: INFORMATION MEASUREMENT OF THE COMPARATIVE QUANTITATIVE EFFICIENCY ON TWO CONCEPTS OF FULL-TIME EQUIVALENT UNIVERSITY FACULTY: THE UNIVERSITY OF SAN FRANCISCO EXAMPLE

THE UNIVERSITY OF SAN FRANCISCO: COLLEGE/SCHOOL	VARIABLE FTE FACULTY			600 SCH-FTE FACULTY		
	FTE	PROPORTION	H	FTE	PROPORTION	H
Business Administration	21.86	.0737	.08347	21.13	.0737	.09151
Education	23.36	.0788	.08695	10.67	.0433	.05904
Evening College	28.13	.0948	.09700	27.33	.1109	.10592
Intersession	3.56	.0120	.02305	3.56	.0144	.02652
Law	29.28	.0987	.08749	29.28	.1188	.10991
Liberal Arts	98.02	.3305	.15891	95.41	.3373	.15955
Nursing	27.90	.0941	.09659	11.16	.0453	.06132
Science	49.72	.1676	.13001	33.81	.1373	.11840
Summer Session	14.76	.0498	.06488	14.03	.0569	.07083
Total	296.59	1.0000	.82835	246.38	1.000	.80300

USE DATAL SOURCES: (1) James Steve Counelis, "Academic Productivity and Institutional-Level Theory: Unobtrusive Measures for the Under-Computerized Institution," in Robert G. Cope (Ed.), Public Policy: Issues and Analyses (Seattle, Wa.: Association for Institutional Research/University of Washington, 1974), pp. 49-57. (2) James Steve Counelis, University Budget Planning, Regression Estimates of Credit and the Concept of FTE Faculty (ERIC No. ED 090 869; San Francisco, CA: The University of San Francisco/Office of Institutional Studies, 1974).

CHART NO. 7: INFORMATION MEASUREMENT OF QUANTITATIVE VARIABILITY IN UNIVERSITY REVENUES AND EXPENDITURES: THE UNIVERSITY OF SAN FRANCISCO EXAMPLE ($ IN 1000'S)

REVENUES		
TYPE	FY 1973-74	FY 1972-73
Student Tuition and Fees	$ 9,664	$ 8,949
Grants: Research and Projects	948	1,073
Restricted Gifts	186	82
Endowment Income	52	66
Student Aid: Gifts and Grants	218	646
Student Aid: Endowment Income	94	87
Other Sources	194	165
Auxiliary Enterprises	2,528	2,325
Total	$13,834	$13,393

EXPENDITURES		
TYPE	FY 1973-74	FY 1972-73
Instruction + Department Administration	$ 5,257	$ 5,194
Research and Projects	1,041	1,122
Libraries	785	976
Computer Operations	170	178
Student Services	407	396
Educational Administration	533	485
Plant: Operation/Maintenance	951	796
General Administration	1,331	1,188
Departmental Student Aid	132	134
Mandatory Transfers	105	23
Auxiliary Enterprises	2,521	2,351
Student Aid	741	1,005
Total	$13,984	$13,847

SOURCE:
Financial Statements and Auditor's Report:
University of San Francisco, June 30, 1974

Revenues Information Measure (H) = 872 x 10^{-5} Nits

Expenditures Information Measure (H) = 724 x 10^{5} Nits

$H = \sum p_i \log_e (q_i/p_i)$

CHART NO. 8: INFORMATION MEASUREMENT OF THE COMPARATIVE PROPORTIONAL VARIABILITY IN UNIVERSITY FINANCES: THE UNIVERSITY OF SAN FRANCISCO EXAMPLE ($ IN 1000'S)

ASSETS			LIABILITIES AND FUND BALANCES		
TYPE	FY 1973-74	FY 1972-73	TYPE	FY 1973-74	FY 1972-73
CURRENT:			CURRENT:		
(1) Cash	$ 1,045	$ 1,247	(1) Liabilities	$ 2,199	$ 2,636
(2) Inventories	100	104			
(3) Prepaid Expenses and Deferred Charges	138	104	FIXED:		
FIXED:			(1) Liabilities	8,225	8,611
(1) Securities	4,618	4,180	(2) Undistributed Net Gain From Investment Transactions	155	141
(2) Restricted Bond Funcs	349	308	(3) Fund Balances	30,429	29,032
(3) Notes and Accounts Receivables	3,602	3,562			
(4) Rancho Olompoli	750	750			
(5) Plant Properties	30,288	30,002			
(6) Other Assets	118	163			
Total	$41,008	$40,420	Total	$41,008	$40,420

SOURCE:
Financial Statements and Auditor's Report:
University of San Francisco, June 30, 1974

Assets Information Measure (H) = 55×10^{-5} Nits

Liabilities Information Measure (H) = 54×10^{-5} Nits

$$H = \Sigma\, q_i \log_e (q_i/p_i)$$

Steve Cornelis

The University of San Francisco 3/75

CHART NO. 9: COMPARATIVE INFORMATION MEASUREMENT OF A UNIVERSITY BALANCE SHEET - SEVERAL UNIVERSITY OF SAN FRANCISCO DECOMPOSITIONS

TIME HORIZON DECOMPOSITION	10^{-5} Nits	ASSETS/LIABILITIES BETWEEN GROUP DECOMPOSITION	10^{-5} Nits
Current Items Information (H)	6	Assets Information (H)	14
Fixed Items Information (H)	-1	Liabilities Information (H)	51
		Total	65
Weighted Mean	1	Rounded Arithmetic Mean	33
Time Horizon Information (H)	32		
Balance Sheet Information (H)	33	Balance Sheet Information (H)	33

Assets/Liabilities Within-Group Decomposition:

Current Assets Information (H):	401×10^{-5} Nits
Fixed Assets Information (H):	28×10^{-5} Nits
Current Liabilities Information (H):	zero Nits
Fixed Liabilities Information (H):	33×10^{-5} Nits

Using Chart Nos. 10-11:

$H = \Sigma\, q_i \log_e (q_i/p_i)$

CHART NO. 10: CROSS-CLASSIFICATION OF UNIVERSITY ASSETS AND LIABILITIES AND THEIR PROPORTIONAL DISTRIBUTION- FY 1973-1974 UNIVERSITY OF SAN FRANCISCO DATA

	ASSETS	LIABILITIES	TOTAL
Current	$1283 q = .01564	$2199 q = .02681	$3482 q = .04246
Fixed	$39,725 q = .48436	$38,809 q = .47319	$78,534 q = .95754
Total	$41,008	$41,008	$82,016

($ In 1000's)

CHART NO. 11: CROSS-CLASSIFICATION OF UNIVERSITY ASSETS AND LIABILITIES AND THEIR PROPORTIONAL DISTRIBUTION- FY 1972-1973 UNIVERSITY OF SAN FRANCISCO DATA

	ASSETS	LIABILITIES	TOTAL
Current	$1455 p = .01800	$2636 p = .03261	$4091 p = .05061
Fixed	$38,965 p = .48200	$37,784 p = .46739	$76,749 p = .94939
Total	$40,420	$40,420	$80,840

($ In 1000's)